Financial Information Integration in the Presence of Equational Ontological Conflicts

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Is there a better way…

• No single international accounting standard exists
  – “90 per cent of institutional investors favored a single international accounting standard, but they differed over what it should be” McKinsey

• Standards and preferences change over time
  – e.g. Worldbank is gradually moving from 1968 System of National Accounts (SNA) to 1993 SNA
  – WorldCom Causes Analysts To Evaluate Ebitda's Role *(WSJ)*

• Local practices are hard to change
  – US adopted(!) the metric standards for length and mass in 1893

… to access disparate financial information?
Roadmap

• Key Concepts
• Solution Methodology
• Prototype
• Concluding Remarks
Equational Ontological Conflicts

# of customers = # of end_customers + # of distributors

Gross Profit = Net Sales – Cost of Goods

P/E Ratio = Price / Earnings(last 4 Qtr)

Price = Nominal Price + Shipping

"heterogeneity in the way data items are calculated from other data items in terms of definitional equations"
EOC between standards


Following current statistical practice, the World Bank has recently adopted the new terminology in line with the 1993 System of National Accounts (SNA). In general, the definitions under the 1993 SNA guidelines remain as before, and only the terminology has changed. **Exceptions are:** GNI in constant prices, which differs from GNP in that it also includes a terms of trade adjustment; and gross capital formation which now includes a third category of capital formation: net acquisition of valuables. Included in gross capital formation under the 1993 SNA are capital outlays on defense establishments that may be used by the general public, such as schools, airfields, and hospitals. These expenses were treated as consumption in the earlier version of the SNA. ”

(I) GNI in constant prices = GNP – Trade Adjustment Term

(II) Gross Capital Formation(New) = Gross Capital Formation(Old) + Net Acquisition of valuables + Capital outlays on defense establishments
Primark was a company that owned:

- **Disclosure**
- **Worldscope**
- **DataStream**
- Information services

### Top 25 International Co. by Net Sales (Worldscope)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Company</th>
<th>Net Sales (000’s)</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mitsubishi Corporation</td>
<td>165,848,468</td>
<td>03/31/96</td>
</tr>
<tr>
<td>2</td>
<td>General Motors Corp</td>
<td>163,861,100</td>
<td>12/31/95</td>
</tr>
<tr>
<td>8</td>
<td>Exxon Corp</td>
<td>107,893,000</td>
<td>12/31/95</td>
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<tr>
<td>16</td>
<td>International Business M</td>
<td>71,940,000</td>
<td>12/31/95</td>
</tr>
<tr>
<td>17</td>
<td>General Electric Co</td>
<td>69,948,000</td>
<td>12/31/95</td>
</tr>
<tr>
<td>20</td>
<td>Mobil Corp</td>
<td>64,767,000</td>
<td>12/31/95</td>
</tr>
</tbody>
</table>

### Top 25 US Co. by Net Sales (Disclosure)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Company</th>
<th>Net Sales (000’s)</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General Motors Corp</td>
<td>168,828,600</td>
<td>12/31/95</td>
</tr>
<tr>
<td>2</td>
<td>Ford Motor Co</td>
<td>137,137,000</td>
<td>12/31/95</td>
</tr>
<tr>
<td>3</td>
<td>Exxon Corp</td>
<td>121,804,000</td>
<td>12/31/95</td>
</tr>
<tr>
<td>4</td>
<td>Wal Mart Stores Inc</td>
<td>93,627,000</td>
<td>01/31/96</td>
</tr>
<tr>
<td>5</td>
<td>AT&amp;T</td>
<td>79,609,000</td>
<td>12/31/95</td>
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<td>6</td>
<td>Mobil Corp</td>
<td>73,413,000</td>
<td>12/31/95</td>
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<tr>
<td>7</td>
<td>International Business M</td>
<td>71,904,000</td>
<td>12/31/95</td>
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<tr>
<td>8</td>
<td>General Electric Co</td>
<td>70,028</td>
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</tr>
<tr>
<td>9</td>
<td>Wal Mart Stores Inc</td>
<td>67,105,000</td>
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<tr>
<td>10</td>
<td>General Electric Co</td>
<td>66,565,000</td>
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<tr>
<td>11</td>
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<td>66,391,000</td>
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<td>65,567,000</td>
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<td>15</td>
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<td>20</td>
<td>Mobil Corp</td>
<td>64,000</td>
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</tbody>
</table>

### Key Concepts
- **EOC in Primark Databases**
Approach: ECOIN

• Context-based loosely-coupled integration

  Extends the Context Interchange (COIN) framework developed at MIT

• Symbolic Equation Solving using Constraint Logic Programming

  Integrates symbolic equation solving techniques with abductive logic programming
ECOIN Framework

Solution Methodology

Context Axioms

Ontology

SEMANTIC RELATIONS

EXTENSIONAL RELATIONS

C0
C1
C2
C3

µ

µ

µ

L1
L2

EXTENSIONAL RELATIONS

SEMANTIC RELATIONS
Context Axioms

Conversion Functions

Constraint Handling Rules

sum(X,Y,Z), bound(Z) \iff sub(Z,Y,X), bound(Z).
mul(X,Y,Z), bound(Z) \iff div(Z,Y,X), bound(Z).
div(X,A,Y), sub(B,Y,X) \iff \text{ground(A), } A \sim -1|
mul(A,B,N1), sum(1,A,N2), div(N1,N2,X).
...

Ontology
ECOIN Framework

Conversion Functions

\[ C_1 : \text{Gross profit} \]
\[ C_2 : \text{Gross profit depreciation subtracted} \]
\[ C_n : \text{Profit tax subtracted} \]

\[ \text{Profit}(c_n) \Rightarrow \text{Gross Profit}(c_1) ? \]

\[ f_{12} : \text{Gross Profit}(c_1) = \text{Gross Profit}(c_2) + \text{Depreciation}(c_2) \]

\[ f_{2n} : \text{Gross Profit}(c_2) - \text{Tax}(c_2) = \text{Profit}(c_n) & \text{Tax}(c_2) = \text{Gross Profit}(c_2) \times \text{Tax Rate}(c_2) \]

Symbolic Equation Solver

\[ (+ \text{Dijkstra's shortest path algorithm}) \]

\[ f_{1n} : \text{Profit}(c_n) + \text{Gross Profit}(c_2) \times \text{Tax Rate}(c_2) + \text{Depreciation}(c_2) \]
ECOIN Framework

• Treats equational ontological conflicts as contextual differences…

C₁: Gross profit
C₂: Gross profit depreciation subtracted
C₃: Profit tax subtracted
ECOIN Framework

- ...as opposed to introducing new terms in the ontology

T₁: Gross profit
T₂: Gross profit depreciation subtracted
T₃: Profit tax subtracted
**E-Business Application**

**Price Equations**

**Context Mediator**

**eToys**

**Kid’s World**

**Prices of Products Cheaper in eToys compared to Kid’s World**

<table>
<thead>
<tr>
<th>Product Code</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>pokemon</td>
<td>13.3</td>
</tr>
<tr>
<td>starwars</td>
<td>30.1</td>
</tr>
</tbody>
</table>

**Query**

**E-Business Application**

**Prototype**

**Price: Nominal**

**Product Code: Numeric**

<table>
<thead>
<tr>
<th>Product Code</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>123456</td>
<td>20</td>
</tr>
<tr>
<td>234567</td>
<td>40</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
Concluding Remarks

- Equational Ontological Conflicts are widespread in financial information systems
- ECOIN provides a loosely-coupled approach to handling EOC with a logical context-based framework
- ECOIN does not require ontologies to be changed immediately, which is a costly process
- It can be also be used to understand the requirements of a standard